3.0 Groundwater Pathway

Results in Brief: 2003 Groundwater Pathway

Groundwater Remedy – During 2003 active restoration of the Great Miami Aquifer continued at the following five groundwater restoration modules:

- South Plume Module, which became operational on August 27, 1993
- South Field Extraction (Phase I) Module, which became operational on July 13, 1998
- South Plume Optimization Module, which became operational on August 9, 1998
- Re-Injection Module, which became operational on September 2, 1998
- Waste Storage Area Module, which became operational on May 8, 2002.

Additionally, Phase II components of the South Field Module became operational in July 2003.

Since 1993

- 14,240 million gallons (53,898 million liters) of water have been pumped from the Great Miami Aquifer
- 1,607 million gallons (6,082 million liters) of water have been re-injected into the Great Miami Aquifer
- 5,599 net pounds (2,542 kg) of uranium have been removed from the Great Miami Aquifer.

During 2003

- 2,428 million gallons (9,190 million liters) of water were pumped from the Great Miami Aquifer
- 360 million gallons (1,363 million liters) of water were re-injected into the Great Miami Aquifer
- 1,151 net pounds (523 kg) of total uranium were removed from the Great Miami Aquifer.

Groundwater Monitoring Results – Uranium concentrations within the 10-year, time-of-travel remediation footprint of the 30 µg/L uranium plume are decreasing significantly.

- Groundwater sampling in the Plant 6 Area indicates that total uranium FRL exceedances detected in 2002 were not present in the second half of 2003. No groundwater remediation module is planned for the Plant-6 Area.
- Groundwater FRL exceedances for uranium occurred in the Waste Storage Area near the southeast corner of the clearwell for the first time. This area will be considered in the design of the Waste Storage Area (Phase II) Module.
- Four new extraction wells, three new re-injection wells, and one injection pond began operating in the South Field Area.

Work was initiated to determine and implement a groundwater remediation approach that results in the most cost-effective groundwater remedy infrastructure, including the wastewater treatment facility, which will remain after site closure. A decision regarding the future aquifer restoration and wastewater treatment approach is anticipated in 2004, following regulatory and stakeholder input to the decision-making process.

On-Site Disposal Facility Monitoring – Leak detection monitoring continued in 2003 for Cells 1 through 6. For those constituents monitored to meet on-site disposal facility requirements, there were no exceedances of groundwater FRLs for either the horizontal till wells or the Great Miami Aquifer wells. Data collected from the cells indicate that the liner systems are performing well within the specifications outlined in the approved cell design.

This chapter provides background information on the nature and extent of groundwater contamination in the Great Miami Aquifer due to past operations at the Fernald site and summarizes:

- Aquifer restoration progress
- Groundwater monitoring activities and results for 2003.

Restoration of the affected portions of the Great Miami Aquifer and continued protection of the groundwater pathway are primary considerations in the accelerated remediation strategy for the Fernald site. The FCP will continue to monitor the groundwater pathway throughout remediation to ensure the protection of this primary exposure pathway.

3.1 Summary of the Nature and Extent of Groundwater Contamination

The nature and extent of groundwater contamination from operations at the Fernald site have been investigated, and the risk to human health and the environment from those contaminants has been evaluated in the Operable Unit 5 Remedial Investigation Report (DOE 1995c). As documented in that report, the primary groundwater contaminant at the site is uranium.

Contamination of the groundwater resulted from infiltration through the bed of Paddys Run, the Storm Sewer Outfall Ditch, and the Pilot Plant Drainage Ditch. In these areas, the glacial overburden is eroded, and the sand and gravel of the aquifer are in direct contact with uranium-contaminated surface water from the site. To a lesser degree, groundwater contamination also resulted where past excavations (such as the waste pits) removed some of the protective clay contained in the glacial overburden and exposed the aquifer to contamination.

Groundwater Modeling at the Fernald Site

The Fernald site uses a computer model to make predictions about how the contaminants in the aquifer will look in the future. Because the model contains simplifying assumptions about the aquifer and the contaminants, the predictions about future behavior must be verified with field measurements obtained from groundwater monitoring activities.

If groundwater monitoring data indicate the need for operational changes to the groundwater remedy, the groundwater model is run to predict the effect those changes might have on the aquifer and the contaminants. If the predictions indicate the proposed changes would increase cleanup efficiency and reduce the cleanup time and cost, the operational changes are made and monitoring data are collected after the changes to verify whether model predictions were correct. If model predictions prove to be incorrect, modifications are made to the model to improve its predictive capabilities.

3.2 Selection and Design of the Groundwater Remedy

While a remedial investigation and feasibility study was in progress and a groundwater remedy was being selected, off-property contaminated groundwater was being pumped from the South Plume area by the South Plume Removal Action System (referred to as the South Plume Module). In 1993 this system was installed south of Willey Road and east of Paddys Run Road to stop the uranium plume in this area from migrating any further to the south. Figure 3-1 shows the South Plume Module Extraction Wells 3924, 3925, 3926, and 3927. These extraction wells have successfully stopped further southern migration of the uranium plume beyond the wells and have contributed to significantly reducing total uranium concentrations in the off-property portion of the plume.

After the nature and extent of groundwater contamination were defined in the Operable Unit 5 Remedial Investigation Report, various remediation technologies were evaluated in the Feasibility Study Report for Operable Unit 5 (DOE 1995a). Remediation cost, efficiency, and various land-use scenarios were considered during the development of the preferred remedy for restoring the quality of the groundwater in the aquifer. The Operable Unit 5 Feasibility Study Report recommended a pump-and-treat remedy for the groundwater contaminated with uranium, consisting of 28 groundwater extraction wells located on- and off-property. Computer modeling suggested that the 28 extraction wells pumping at a combined rate of 4,000 gallons per minute (gpm) (15,140 liters per minute [Lpm]) would remediate the aquifer within 27 years.

The recommended groundwater remedy was presented to EPA, OEPA, and stakeholders in the Proposed Plan for Operable Unit 5 as the Preferred Groundwater Remedy (DOE 1995b). Once the Proposed Plan was approved, the Operable Unit 5 Record of Decision was presented to stakeholders and subsequently approved by EPA and OEPA in January 1996. The Operable Unit 5 Record of Decision (DOE 1996) formally defines the selected groundwater remedy and establishes FRLs for all constituents of concern.

Re-Injection at the Fernald Site

Re-injection is an enhancement to the groundwater remedy. Groundwater pumped from the aquifer is treated to remove contaminants and then re-injected into the aquifer at strategic locations. Because the treatment process is not 100 percent efficient, a small amount of uranium is re-injected into the aquifer with the treated water. The re-injected groundwater increases the speed at which dissolved contaminants move through the aquifer and are pulled by extraction wells, thereby decreasing the overall remediation time.

The Operable Unit 5 Record of Decision commits to an ongoing evaluation of innovative remediation technologies so that remedy performance can be improved as such technologies become available. As a result of this commitment, an enhanced groundwater remedy was presented in the Operable Unit 5 Baseline Remedial Strategy Report, Remedial Design for Aquifer Restoration (Task 1) (DOE 1997a). Groundwater modeling studies conducted to design the enhanced groundwater remedy suggested that, with the early installation of additional extraction wells and the use of re-injection technology, the remedy could potentially be reduced to 10 years. EPA and OEPA approved the enhanced groundwater remedy that relies on pump-and-treat and re-injection technology. As discussed below, the enhanced groundwater remedy is being used to conduct a concentration-based cleanup of the Great Miami Aquifer.

Evolution of the enhanced groundwater remedy has been documented through a series of approved designs. Specifically, they are: The Operable Unit 5 Baseline Remedial Strategy Report, Remedial Design for Aquifer Restoration (Task 1) (DOE 1997a), Design for Remediation of the Great Miami Aquifer in the Waste Storage and Plant 6 Areas (DOE 2001a), and Design for Remediation of the Great Miami Aquifer South Field (Phase II) Module (DOE 2002c).

The enhanced groundwater remedy commenced in 1998 with the start-up of the South Field (Phase I), South Plume Optimization, and Re-Injection Demonstration Modules. It focuses primarily on the removal of uranium, but has also been designed to limit the further expansion of the plume, achieve removal of all targeted contaminants to concentrations below designated FRLs, and prevent undesirable groundwater drawdown impacts beyond the site's boundary.

Start-up of the enhanced groundwater remedy included a year-long re-injection demonstration that was initiated in September 1998. The Re-Injection Demonstration Test Report (DOE 2000) details the demonstration and recommends its incorporation into the site's aquifer restoration strategy. Based on the results of the demonstration, re-injection is continuing at the site. Through the years, additional extraction and re-injection wells have been added to these initial restoration modules.

In 2001 the EPA and OEPA approved the Design for Remediation of the Great Miami Aquifer in the Waste Storage and Plant 6 Areas. Approval of this design initiated the installation of the next planned aquifer restoration module. The design specified three extraction wells in the Waste Storage Area (Phase I) to address contamination in the Pilot Plant Drainage Ditch plume and two extraction wells (Phase II) to address the remaining contamination after the waste pit excavation is completed. One of the three Waste Storage Area (Phase I) wells was installed in 2000 to support an aquifer pumping test to help determine the restoration well field design. The remaining two Phase I wells were installed in the summer of 2001 after the design was approved by EPA and OEPA. All three wells became operational on May 8, 2002.

The Design for Remediation of the Great Miami Aquifer in the Waste Storage and Plant 6 Areas also provided data indicating that the uranium plume in the Plant 6 Area was no longer present. It was believed that the uranium plume had dissipated to concentrations below the FRL as a result of the shut-down of plant operations in the late 1980s and the pumping of highly contaminated perched water as part of the Perched Water Removal Action #1 in the early 1990s. Because a uranium plume with concentrations above the groundwater FRL was no longer present in the Plant 6 Area at the time of the design, a restoration module for the area was determined to be unnecessary. Groundwater monitoring continued in the Plant 6 Area with one well in the area having total uranium FRL exceedances in 2002; however, in 2003 uranium concentrations were once again below the total uranium FRL. Direct-push sampling will be conducted in the Plant 6 Area to document the vertical profile at the location where the 2002 total uranium FRL exceedances occurred. (Uranium plume maps will continue to show a small uranium plume in the Plant 6 Area until direct-push sampling has been conducted.)

In 2002 the EPA and OEPA approved the next planned groundwater restoration design document, the Design for Remediation of the Great Miami Aquifer South Field (Phase II) Module. The Phase II design presents an updated interpretation of the uranium plume in the South Field area along with recommendations on how to proceed with remediation in the area based on the updated plume interpretation. Installation of Phase II components was initiated in 2002. The overall system, both Phase I and Phase II, will henceforth be referred to as the South Field Module.

During 2003 active remediation of the Great Miami Aquifer continued at the South Plume/South Plume Optimization, South Field, Waste Storage Area, and Re-Injection Modules. Figure 3-1 depicts the current extraction and re-injection well locations. The operational information associated with these modules is presented in subsequent subsections. In 2003 South Field (Phase II) Module components installed in 2002 became operational for the first time. The new components consist of four new extraction wells (Extraction Wells 33262 or 15a, 33264 or EW-30, 33265 or EW-31, and 33266 or EW-32), one new re-injection well (Re-Injection Well 33263 or IW-29), conversion of an existing extraction well into a re-injection well (Re-Injection Well 31563 or IW-16), and installation of a re-injection pond. Figure 3-2 identifies current and future extraction and re-injection well locations. At the end of 2003, the only remaining planned enhanced groundwater remedy module component, pending design and installation, was the Phase II component of the Waste Storage Area Module (to become operational in 2006). Design and installation of this remaining component is pending completion of the waste pit excavations.

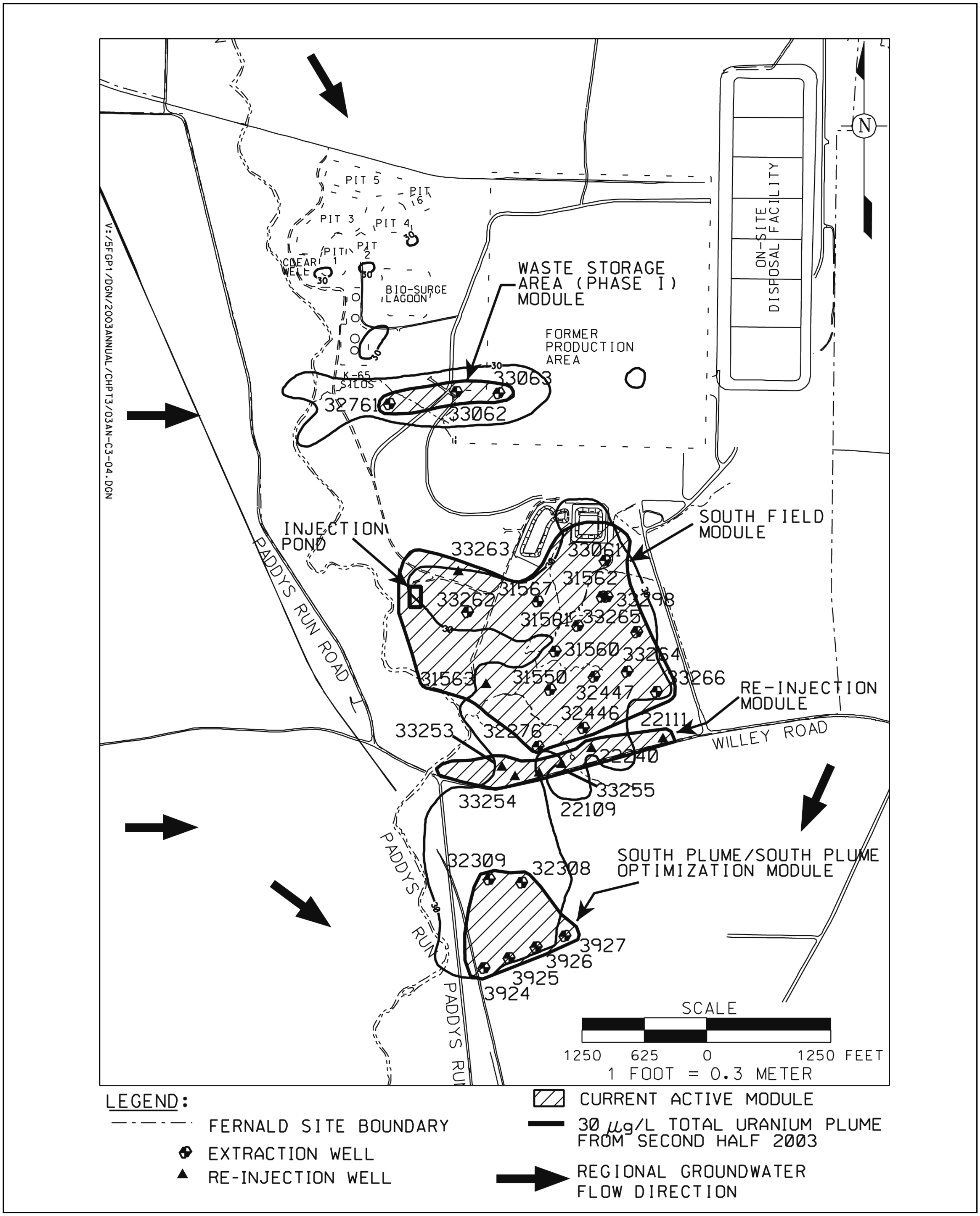


Figure 3-1. Current Extraction and Re-Injection Wells

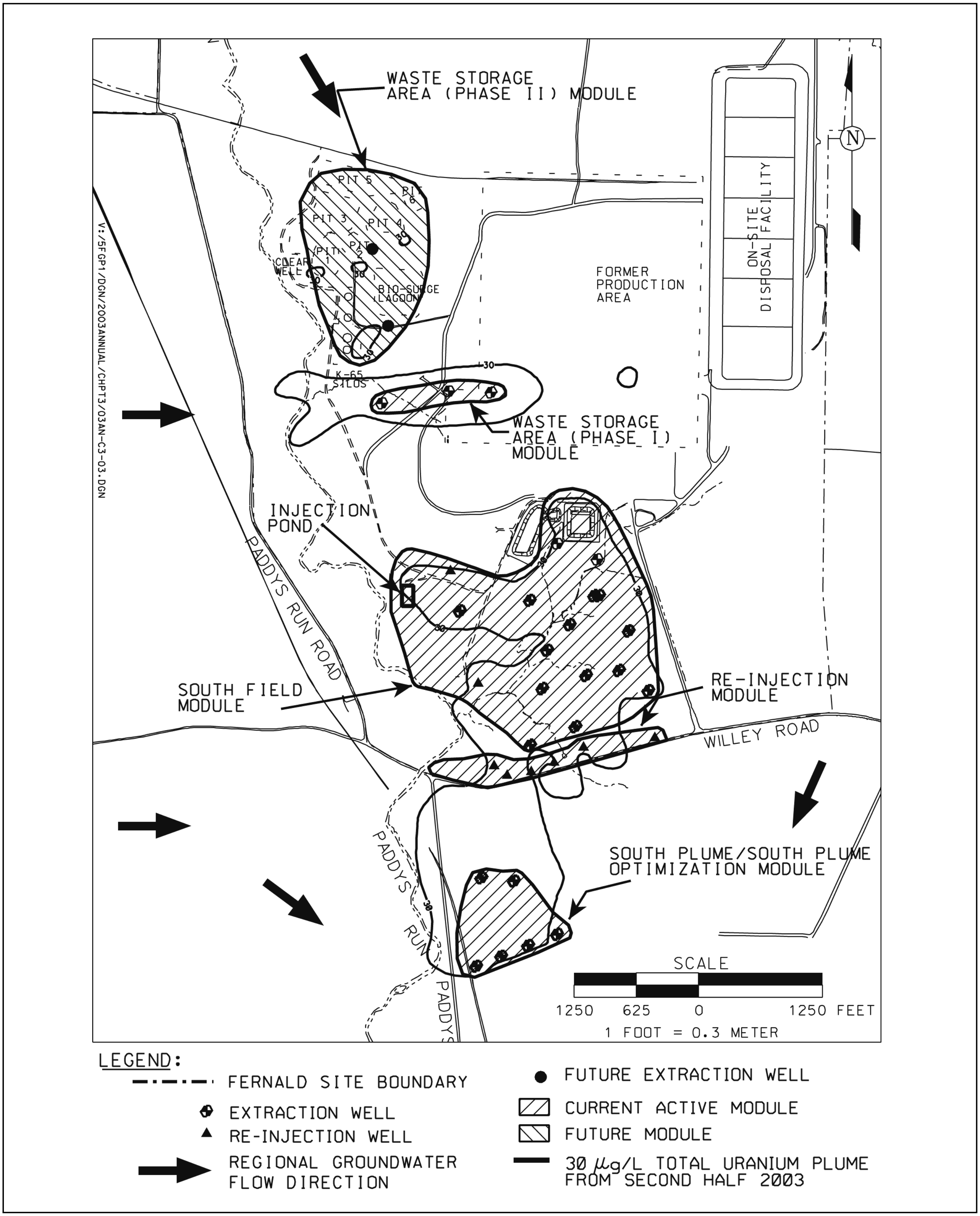


Figure 3-2. Current and Future Extraction and Re-Injection Wells for the Groundwater Remedy

Work was initiated in 2003 to determine and implement a groundwater remediation approach that results in the most cost-effective groundwater remedy infrastructure, including the wastewater treatment facility, which will remain after site closure. An evaluation of the alternatives was contained within a draft report titled, Comprehensive Groundwater Strategy Report (DOE 2003c). In October 2003 initial discussions were held with the regulators and the public concerning the various alternatives identified in the report. These discussions culminated in an identified path forward to work collaboratively with the Fernald Citizens Advisory Board, EPA, and OEPA to determine the most appropriate course of action for the ongoing aquifer restoration and water treatment activities at the FCP. A decision regarding the future aquifer restoration and wastewater treatment approach is anticipated in 2004, following regulatory and stakeholder input to the decision-making process.

3.3 Groundwater Monitoring Highlights for 2003

For this annual site report, groundwater monitoring results are discussed in terms of restoration and compliance monitoring.

The key elements of the Fernald site groundwater monitoring program design are described below. Note that with the implementation of the IEMP, Revision 3, in 2003, the groundwater monitoring approach was streamlined to focus on areas where exceedances (total uranium and non-uranium) were occurring while continuing to meet compliance requirements.

- **Sampling** – Sample locations, frequency, and the constituents were selected to address operational assessment, restoration assessment, and compliance requirements. Selected wells are monitored for up to 50 groundwater FRL constituents. Monitoring is conducted to ascertain groundwater quality and groundwater flow direction. Figure 3-3 shows a typical groundwater monitoring well at the site and Figure 3-4 identifies the relative placement depths of groundwater monitoring wells at the site. As part of the comprehensive IEMP groundwater monitoring program, approximately 150 wells were monitored for water quality in 2003. Figures 3-5 (total uranium monitoring) and 3-6 (non-uranium monitoring) identify the locations of the current IEMP water quality monitoring wells. In addition to water quality monitoring, approximately 170 wells were monitored quarterly for groundwater elevations. Figure 3-7 depicts the IEMP routine water level (groundwater elevation) monitoring wells, including extraction wells.

- **Data Evaluation** – The integrated data evaluation process involves looking at the data collected from wells to determine capture and restoration of the uranium plume; capture and restoration of non-uranium FRL constituents; water quality conditions in the aquifer that indicate a need to modify the design and installation of restoration modules; and the impact of ongoing groundwater restoration on the Paddys Run Road Site plume (a separate contaminant plume south of the Fernald site along Paddys Run Road resulting from independent industrial activities in the area).

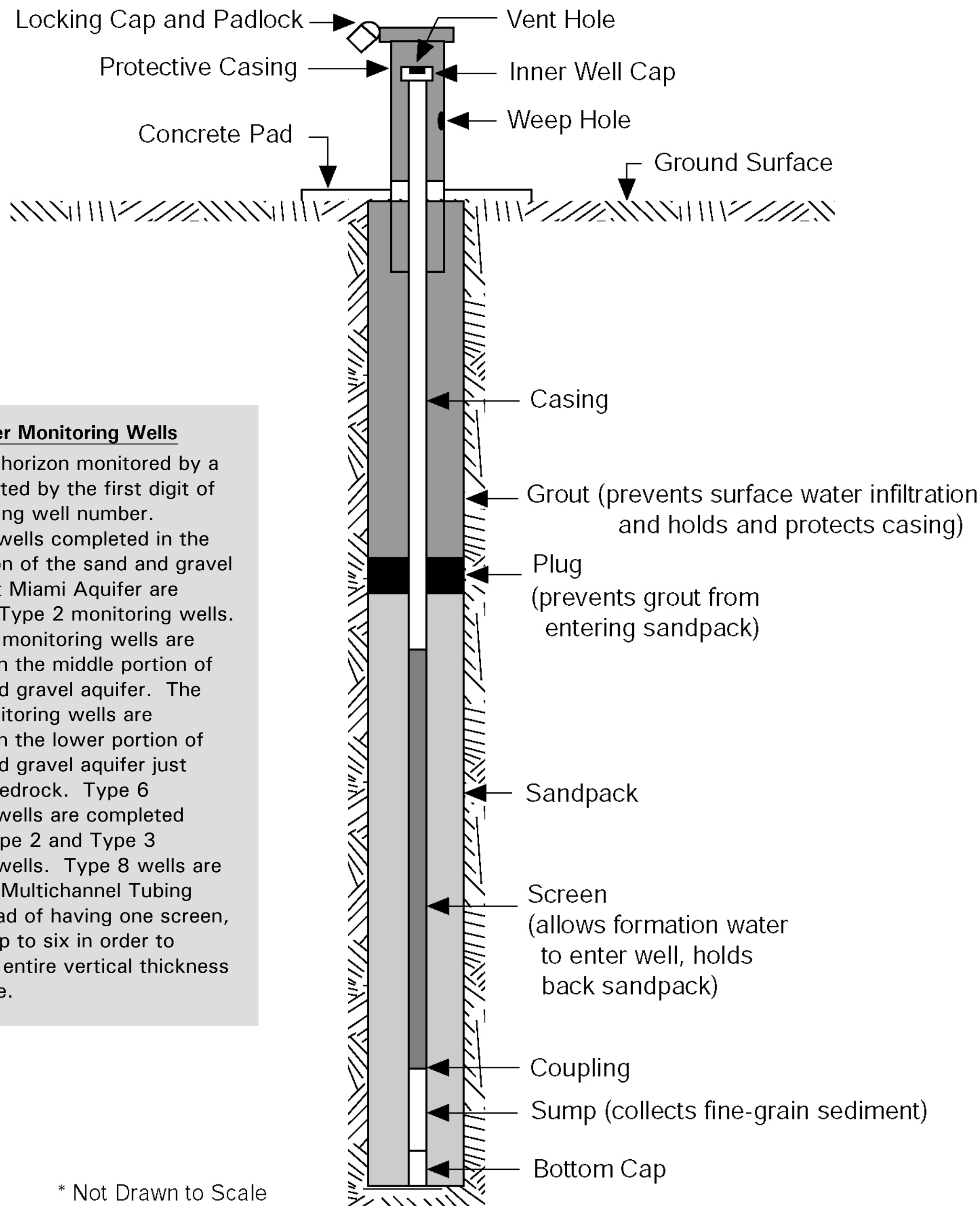
- **Reporting** – All data are reported through the IEMP program mid-year data summary and annual site environmental reports.

3.3.1 Restoration Monitoring

In general, restoration monitoring tracks the progress of the groundwater remedy and water quality conditions. Restoration monitoring is discussed in the subsections that follow.

All operational modules were evaluated during the year to determine the progress of aquifer remediation. The evaluation was done by collecting and mapping groundwater quality and groundwater elevation data and then analyzing the results. Concentration maps are developed from analytical data and compared with groundwater elevation maps depicting the location of capture zones.

More detailed information can be found in Appendix A of this report. Subsections that follow identify the specific attachment of Appendix A where the detailed information can be found.



Groundwater Monitoring Wells

The aquifer horizon monitored by a well is denoted by the first digit of the monitoring well number. Monitoring wells completed in the upper portion of the sand and gravel of the Great Miami Aquifer are denoted as Type 2 monitoring wells. The Type 3 monitoring wells are completed in the middle portion of the sand and gravel aquifer. The Type 4 monitoring wells are completed in the lower portion of the sand and gravel aquifer just above the bedrock. Type 6 monitoring wells are completed between Type 2 and Type 3 monitoring wells. Type 8 wells are Continuous Multichannel Tubing wells; instead of having one screen, they have up to six in order to monitor the entire vertical thickness of the plume.

Figure 3-3. Diagram of a Typical Groundwater Monitoring Well

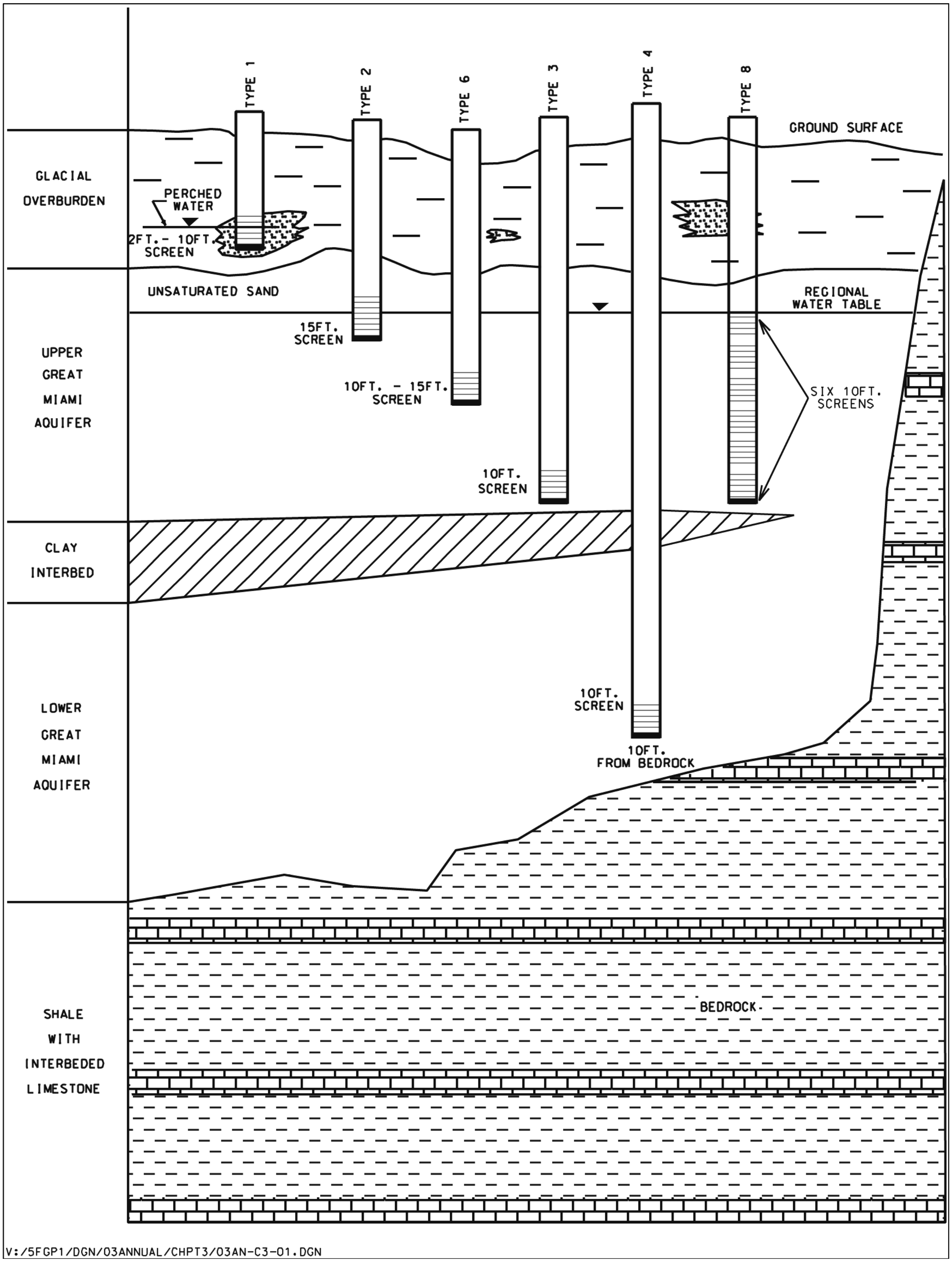


Figure 3-4. Monitoring Well Relative Depths and Screen Locations

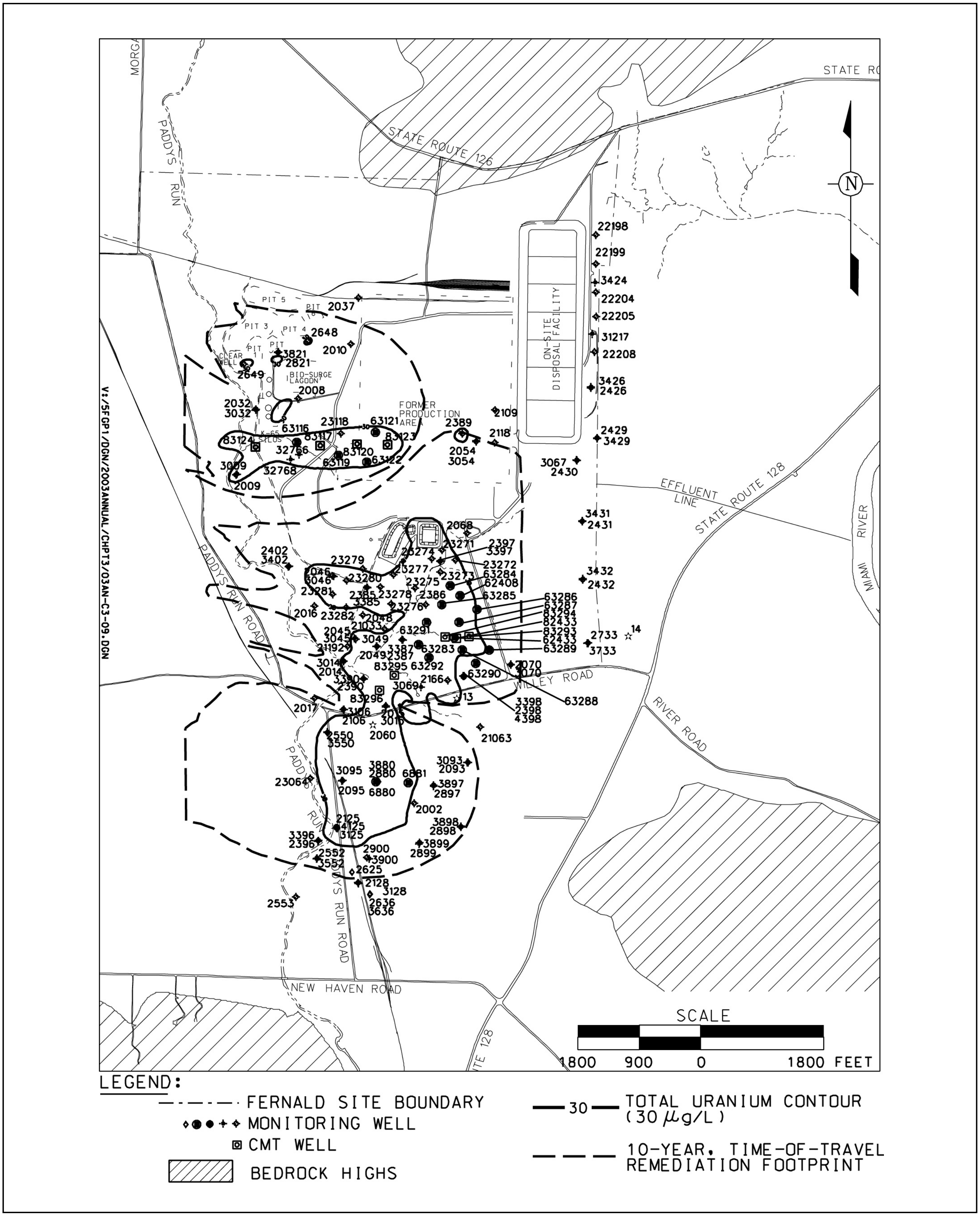


Figure 3-5. Locations for Semi-Annual Total Uranium Monitoring

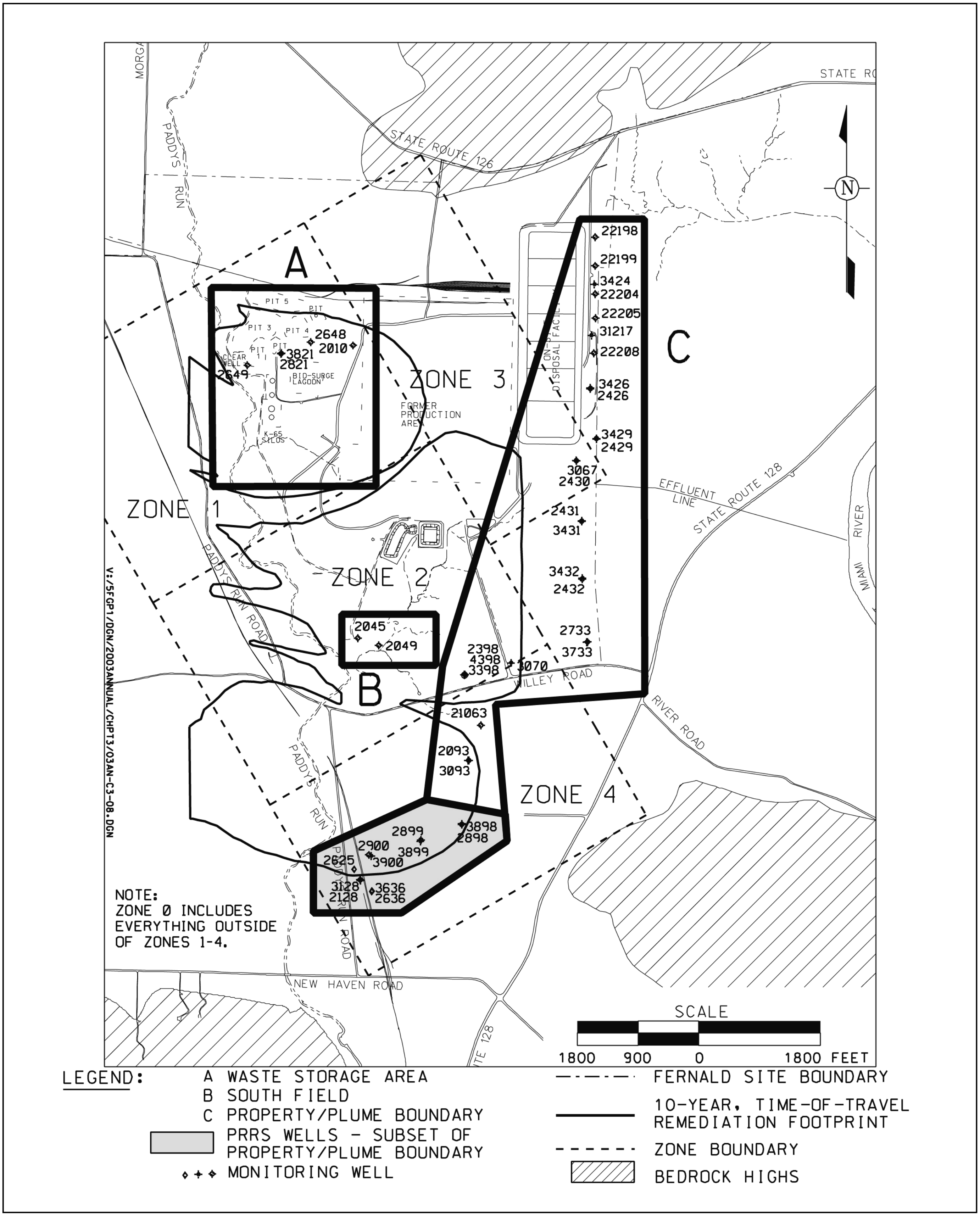


Figure 3-6. Locations for Semi-Annual Non-Uranium Monitoring

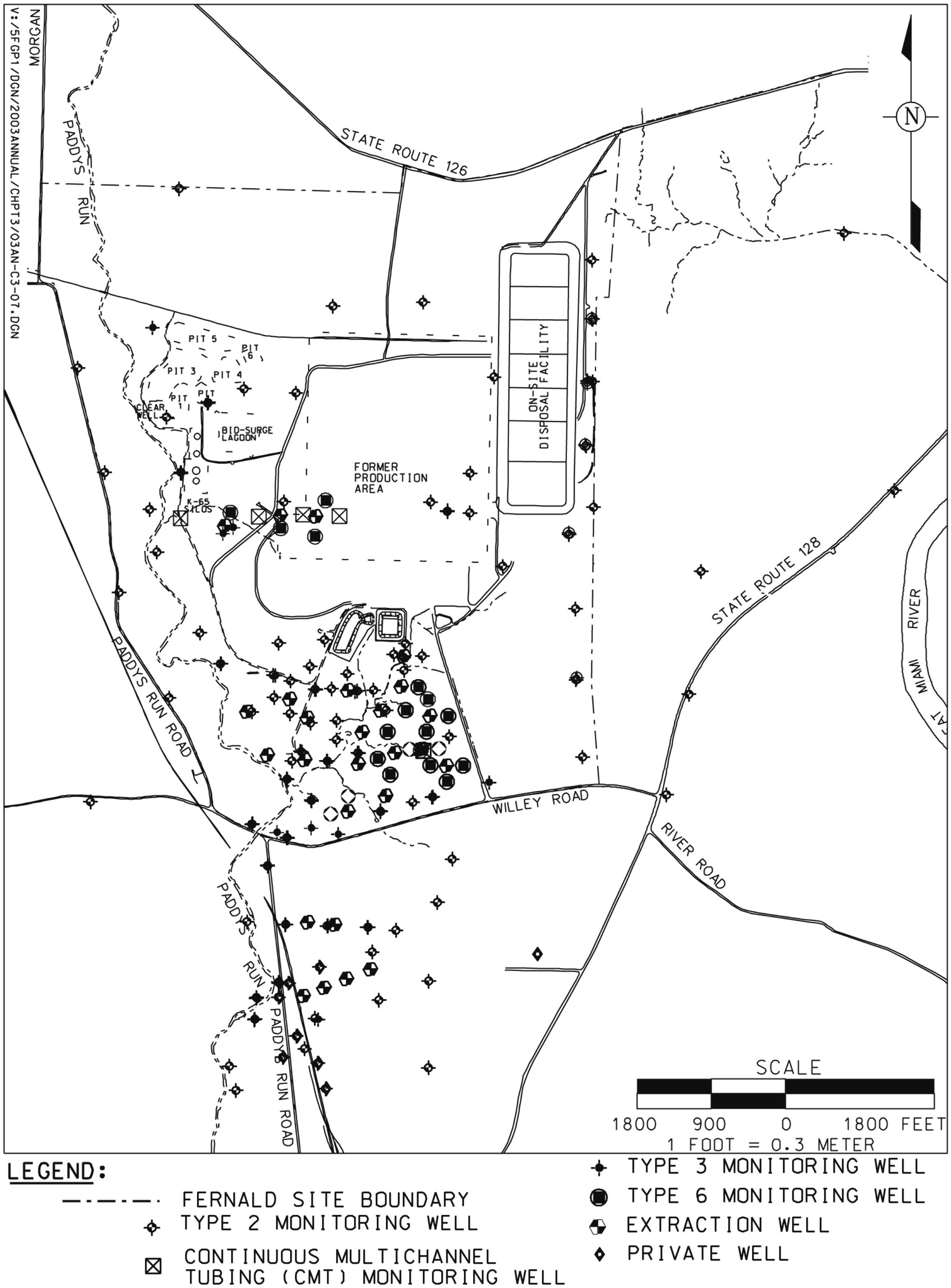


Figure 3-7. IEMP Groundwater Elevation Monitoring Wells

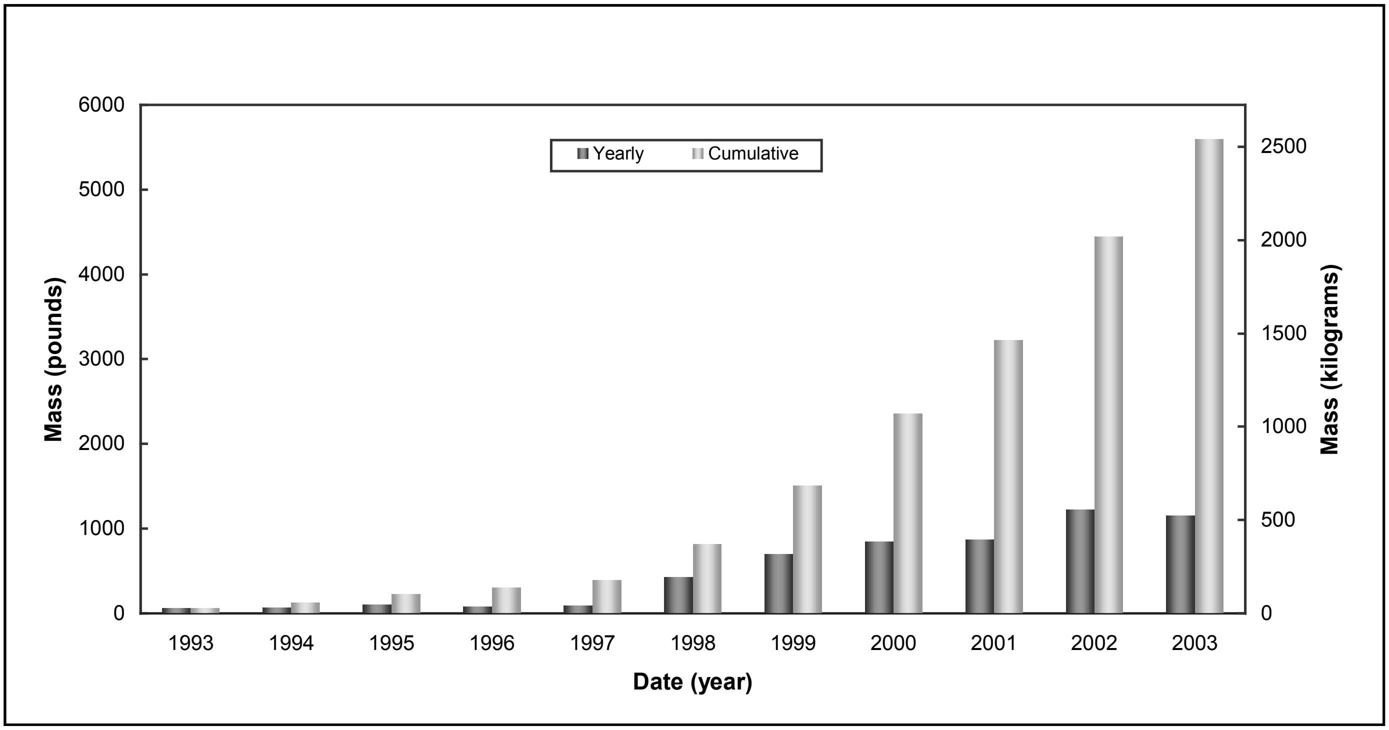


Figure 3-8. Net Pounds of Uranium Removed from the Great Miami Aquifer, 1993-2003

3.3.1.1 Operational Summary

Figure 3-1 shows the extraction and re-injection well locations associated with the current restoration modules. With the exception of the Waste Storage Area, all wells currently planned for the enhanced groundwater remedy have been installed. Table 3-1 summarizes the pounds of uranium removed, amount of groundwater pumped, pounds of uranium re-injected, and amount of treated groundwater re-injected by the active restoration modules during 2003. For reporting purposes, operational data for the re-injection wells located in the South Field as well as the Injection Pond (which is also located in the South Field) are tabulated with the Re-Injection Module operational data in Table 3-1. Figure 3-8 identifies the yearly and cumulative pounds of uranium removed from the Great Miami Aquifer from 1993 through 2003. Since 1993:

- 14,240 million gallons (53,898 million liters) of water have been pumped from the Great Miami Aquifer
- 1,607 million gallons (6,082 million liters) of treated water have been re-injected into the Great Miami Aquifer
- 5,599 net pounds (2,542 kg) of total uranium have been removed from the Great Miami Aquifer.

Appendix A, Attachment A.1, of this report provides detailed operational information on each extraction and re-injection well, such as pumping and re-injection rates, uranium removal indices, and total uranium concentration graphs. The following subsections provide overview information on the individual modules.

TABLE 3-1
GROUNDWATER RESTORATION MODULE STATUS FOR 2003

Module	Restoration Wells	Target Pumping Rate		Gallons Pumped/ (Gallons Re-Injected)		Uranium Removed/ (Re-Injected)	
		gpm	Lpm	M gal	M liters	lbs	kg
South Plume/ South Plume Optimization Module	3924 3925 3926 3927 32308 32309	1,900	7,192	799	3,024	177	80
South Field Module	31550 31560 31561 31562[a] 31563[b] 31564[c] 31565[d] 31566[e] 31567 32276 32446 32447 33061 33298 33262 33264 33265 33266	3,365[j]	12,737	1,081	4,092	622	282
Waste Storage Area Module	32761 33062 33063	1,100	4,164	548	2,074	363	165
Re-Injection Module and South Field Re-Injection Wells and Pond	22107[f] 22108[g] 22109 22240 33253 33254 33255 33263[h] 31563[h] Injection Pond[i]	(1,425)	(5,394)	(360)	(1,363)	(10.58)	(4.80)
Aquifer Restoration System Totals							
pumped		6,365	24,093	2,428	9,190	1,162	527
(re-injected)		(1,425)	(5,394)	(360)	(1,363)	(10.58)	(4.80)
net		4,940	18,699	2,068	7,827	1,151	523

[a]Extraction Well 31562 began operating in July 1998. It was removed from service in March 2003 and was replaced by Extraction Well 33298 which became operational on July 29, 2003.

[b]Extraction Well 31563 began operating in July 1998. It was removed from service in December 2002.

[c]Extraction Well 31564 began operating in July 1998. It was removed from service in December 2001.

[d]Extraction Well 31565 began operating in July 1998. It was removed from service in May 2001.

[e]Extraction Well 31566 began operating in July 1998. It was removed from service in August 1998.

[f]Re-injection Well 22107 began operating in August 1998. It was replaced by Re-Injection Well 33253 in November 2002.

[g]Re-injection Well 22108 began operating in August 1998. It was replaced by Re-Injection Well 33254 in November 2002.

[h]Re-Injection Wells 33263 and 31563 are located in the South Field.

[i]Injection Pond is located in the South Field.

[j]Target pumping rate as of July when South Field (Phase II) Module components came online. Prior to July, the target pumping rate was 2,365 gpm (8,952 Lpm).

3.3.1.2 South Plume/South Plume Optimization Module Operational Summary

The four extraction wells of the South Plume Module (Extraction Wells 3924, 3925, 3926, and 3927) began operating in August 1993. The two extraction wells of the South Plume Optimization Module (Extraction Wells 32308 and 32309) began operating in August 1998. Figure 3-9 illustrates the uranium plume capture observed for the South Plume/South Plume Optimization Module in the fourth quarter of 2003. During 2003, 799 million gallons (3,024 million liters) of groundwater and 177 pounds (80 kg) of uranium were removed from the Great Miami Aquifer by the South Plume/South Plume Optimization Module. Based on analysis of the data in 2003, the module continues to meet its primary objectives as demonstrated by the following:

- Southward movement of the uranium plume beyond the southern most extraction wells has not been detected.
- Active remediation of the central portion of the off-property uranium plume continues to reduce plume concentration. Nearly the entire off-property uranium plume concentration is now below 100 µg/L. At the start of pumping in 1993, areas in the off-property uranium plume had concentrations over 300 µg/L.
- Paddys Run Road Site plume, located south of the extraction wells, is not being adversely affected by the pumping.

3.3.1.3 South Field Module Operational Summary

The South Field Module was constructed in two phases. Phase I began operating in July 1998 and Phase II began operating in July 2003. The 10 original extraction wells installed under Phase I were 31550, 31560, 31561, 31562, 31563, 31564, 31565, 31566, 31567, and 32276. Four of the original 10 wells have been shutdown (31564, 31565, 31566, and 31563). Extraction Wells 31564 and 31565 were shut down in December 2001 and May 2001, respectively, to accommodate soil remedial activities. Extraction Well 31566 was shut down in August 1998, and was replaced by Extraction Well 33262, which was installed as part of South Field (Phase II) Module. Extraction Well 31563 was shut down in December 2002 and converted to a re-injection well that began operating in 2003. With the exception of Extraction Well 31563, the locations of the extraction wells that were shut down were all upgradient of the current uranium plume where concentrations in the Great Miami Aquifer are now below the associated FRL.

Three new extraction wells (Extraction Wells 32446, 32447, and 33061) were added to the South Field Module between 1998 and 2002. These three new extraction wells were installed in the eastern, downgradient portion of the South Field plume, at locations where total uranium concentrations were considerably above the associated FRL. Two of the three new wells (32446 and 32447) were installed in late 1999 and began pumping in February 2000. Extraction Well 33061 was installed in 2001 and became operational in 2002.

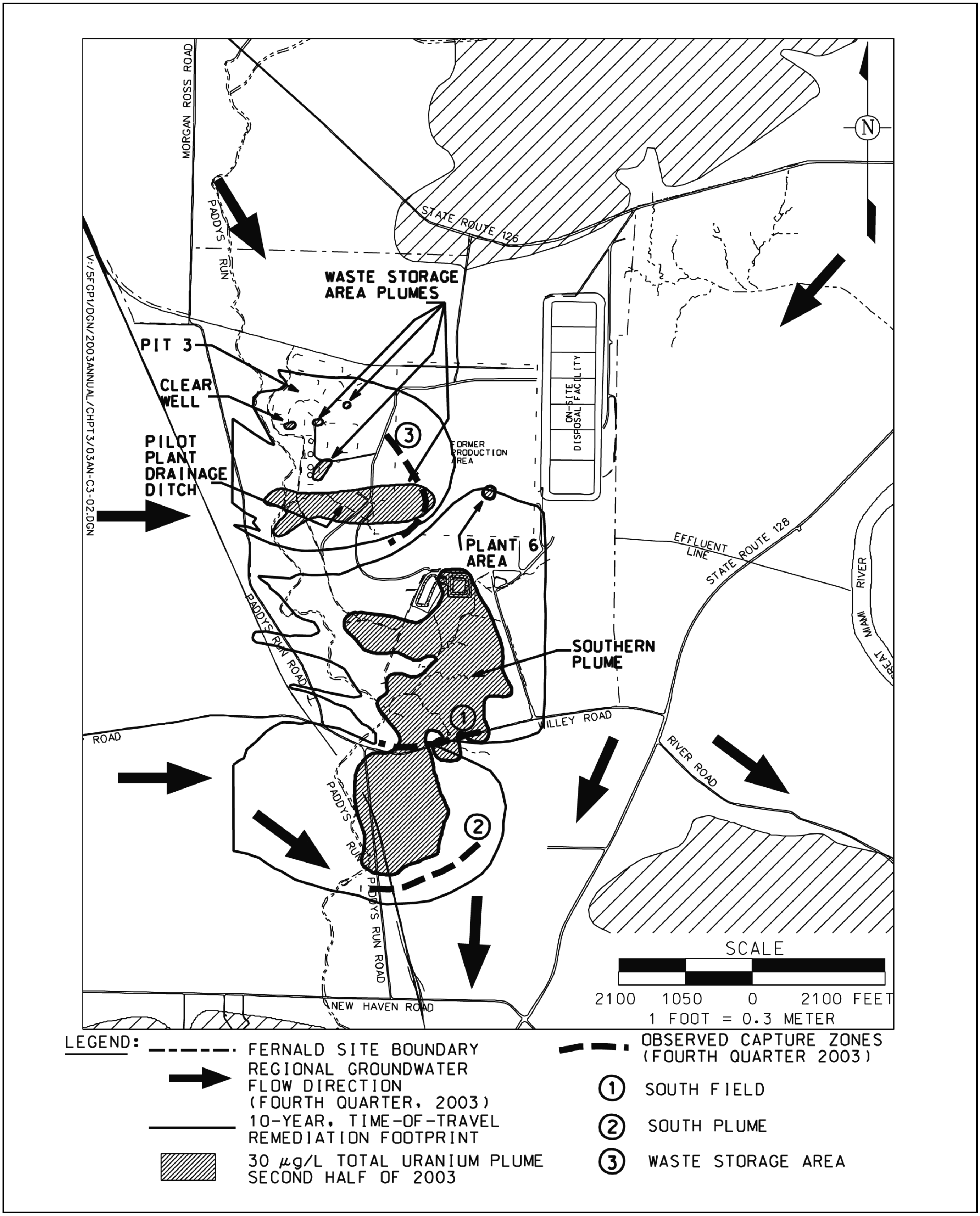


Figure 3-9. Total Uranium Plume in the Aquifer with Concentrations Greater than 30 µg/L at the End of 2003

Phase II components of the South Field Module are described in the Design for Remediation of the Great Miami Aquifer, South Field (Phase II) Module, which was issued in May of 2002. The design provides an updated characterization of the uranium plume in the Great Miami Aquifer beneath the southern portion of the Fernald site and a modeled design for the South Field Module located in that area. All Phase II design components became operational in 2003. The components include:

- Four additional extraction wells, one in the southern waste unit area (Extraction Well 33262), and three along the eastern edge of the on-property portion of the southern uranium plume (Extraction Wells 33264, 33265, and 33266).
- One additional re-injection well in the southern waste unit area (Re-Injection Well 33263).
- A converted extraction well (Extraction Well 31563), which was converted into a re-injection well.
- An injection pond, which is located in the western portion of the Southern Waste Units Excavations.

Figure 3-9 illustrates the capture zone observed for the South Field Module in the fourth quarter of 2003. During 2003, 1,081 million gallons (4,092 million liters) of groundwater and 622 pounds (282 kg) of uranium were removed from the Great Miami Aquifer by the South Field Module.

3.3.1.4 Re-Injection Module Operational Summary

The use of re-injection at the FCP began with a demonstration test that was conducted from September 2, 1998 to September 2, 1999. The demonstration indicated that re-injection was a viable technology for the aquifer remedy. Based on the success of the demonstration, it was decided to incorporate re-injection technology into the aquifer remedy. A Re-Injection Demonstration Test Report (DOE 2000) detailing the demonstration was issued to EPA and OEPA on May 30, 2000.

The original Re-Injection Module consisted of five re-injection wells (Re-Injection Wells 22107, 22108, 22109, 22111, and 22240). Residual plugging of the re-injection wells became a concern in the last half of 2000. During 2001 the re-injection wells were subjected to the new treatment method and this new process was economically viable in three of the five original wells (Re-Injection Wells 22109, 22111, and 22240). It was determined that it was more cost-effective to replace the other two wells (Re-Injection Wells 22107 and 22109) rather than attempt another treatment.

Re-Injection Well 22107 was replaced by Re-Injection Well 33253. Re-Injection Well 22108 was replaced by Re-Injection Well 33254. These two new replacement wells began operating in November 2002. In addition to the two new replacement wells, a sixth re-injection well was added to the module (Re-Injection Well 33255). This new re-injection well is located half way between Re-Injection Wells 22109 and 22240, and began operating on May 22, 2003. During 2003, 360 million gallons (1,363 million liters) of groundwater and 10.58 pounds (4.8 kg) of uranium were re-injected into the Great Miami Aquifer by the Re-Injection Module wells and re-injection wells, and the Injection Pond in the South Field Module.

3.3.1.5 Waste Storage Area (Phase I) Operational Summary

The Waste Storage Area Module became operational on May 8, 2002, nearly 17 months ahead of the Operable Unit 5 Remedial Action Work Plan established start date of October 1, 2003. The module consists of three extraction wells: 32761, 33062, and 33063. These three wells were installed to remediate a uranium plume in the Pilot Plant Drainage Ditch area, according to the Design for Remediation of the Great Miami Aquifer in the Waste Storage and Plant 6 Areas (DOE 2001a). Figure 3-9 illustrates the capture zone observed for the Waste Storage Area Module in the fourth quarter of 2003. During 2003, 548 million gallons (2,074 million liters) and 363 pounds (165 kilograms) of uranium were removed from the Great Miami Aquifer by the Waste Storage Area Module.

3.3.1.6 Monitoring Results for Total Uranium

The 10-year, time-of-travel remediation footprint is an updated model prediction. It illustrates how far a particle of water will travel in response to pumping over a 10-year time period using current pumping locations and target pumping rates for 2003. It replaces the 10-year, uranium-based restoration footprint that was prepared several years ago based on previous model predictions using previous pumping locations and rates that are no longer relevant.

Total uranium is the primary FRL constituent because it is the most prevalent site contaminant and has impacted the largest area of the aquifer. Figure 3-9 shows general groundwater flow directions observed during the fourth quarter of 2003 and the interpretation of the uranium plume in the aquifer updated through the second half of 2003. The shaded areas represent the interpreted size of the maximum uranium plume that is above the 30 μg/L groundwater FRL for total uranium. As of December 31, 2003, approximately 179 acres (72 hectares) of the Great Miami Aquifer were contaminated above the 30 μg/L groundwater FRL for total uranium. Capture zones observed during the fourth quarter of 2003 for the active restoration modules are also identified on Figure 3-9. These capture zones indicate that the southern plume is being captured by the existing system and that further movement of uranium to the south of the extraction wells is being prevented. Figure 3-9 also depicts the 10-year, time-of-travel remediation footprint that was predicted using 2003 target pumping rates.

Geoprobe® (Direct-Push Sampling)

The Geoprobe®, a hydraulically powered, direct-push sampling tool, is used at the Fernald site to obtain groundwater samples at specific intervals without installing a permanent monitoring well. Direct-push means that the tool employs the weight of the vehicle it is mounted on and percussive force to push into the ground without drilling (or cutting) to displace soil in the tool's path. The FCP uses this technique to collect data on the progress of aquifer restoration and to determine the optimal location and depth of additional monitoring and extraction wells that may be installed in the future.

Waste Storage Area – In 2003 FRL exceedances for uranium were detected in the Great Miami Aquifer near the southeast corner of the clearwell. Prior to 2003 the maximum uranium concentration at this location was 15.3 μg/L. The concentration on January 30, 2003 was 35.2 μg/L, and on July 14, 2003 it was 34.7 μg/L. These changing conditions will be considered in the design for the Waste Storage (Phase II) Groundwater Restoration Module. Two Type 8 monitoring wells in the Pilot Plant Drainage Ditch Plume had uranium concentrations that were considerably higher than previously measured maximum concentrations. Both of these monitoring wells are within capture of the nearby operating Waste Storage Area Extraction Wells. Additional information can be found in Appendix A, Attachment A.2.

Plant 6 Area – Data collected for the Design for Remediation of the Great Miami Aquifer in the Waste Storage and Plant 6 Areas (DOE 2001a) indicated that the uranium plume in the Plant 6 Area was no longer present. Therefore, no restoration wells are planned for the Plant 6 Area. However, groundwater monitoring in 2002 detected total uranium FRL exceedances at Monitoring Well 2389, which is located in the Plant 6 Area. On June 12, 2002 the uranium concentration at Monitoring Well 2389 was 40.9 μg/L, and on October 21, 2002 the uranium concentration was 36.7 μg/L. In 2003, however, the uranium concentration at Monitoring Well 2389 decreased below the groundwater FRL. On June 12, 2003 the uranium concentration was 30 μg/L, and on October 13, 2003 the uranium concentration was 11.8 μg/L. A small uranium plume will remain on the uranium plume maps in the Plant 6 Area until direct-push samples can be collected from the area next to Monitoring Well 2389 to document that no FRL exceedances are present through a vertical profile of the aquifer.

South Field and South Plume Areas – In addition to uranium concentration data collected in 2003 from the monitoring well network, 25 different locations were sampled using direct-push methods (six locations in the South Field, seven locations along Willey Road, and 12 locations in the off-property South Plume).

Data collected in 2003 indicate that uranium concentrations continue to decrease in the South Field and South Plume Areas in response to remediation activities. Six direct-push sampling locations in the South Field were revisited in 2003 to measure changes in uranium concentrations. The results document that uranium concentrations have decreased at the sampling locations. The most dramatic decrease was just north of Willey Road where the measured uranium concentration between 1996 and 2003 dropped 488 μg/L in response to pumping and re-injection. Direct-push sampling at 12 locations in the off-property South Plume reveals that uranium concentrations for most of the area are now below 100 μg/L.

Appendix A, Attachment A.2, of this report provides individual monitoring well total uranium results and detailed uranium plume maps for 2003. Appendix A, Attachment A.3, of this report provides quarterly groundwater elevation maps and capture zone interpretations, along with graphical displays of groundwater elevation data.

3.3.1.7 Monitoring Results for Non-Uranium Constituents

Although the enhanced groundwater remedy is primarily targeting remediation of the uranium plume, other FRL constituents contained within the uranium plume are also being monitored. Figure 3-10 identifies the locations of the wells that had non-uranium FRL exceedances , and Table 3-2 summarizes the results of monitoring for non-uranium FRL exceedances. Table 3-2 shows the number of wells exceeding the FRL in 2003; the number of wells exceeding the FRL outside the 10-year, time-of-travel remediation footprint; the groundwater FRL; and the range of 2003 data inside or outside the 10-year, time-of-travel remediation footprint.

TABLE 3-2
NON-URANIUM CONSTITUENTS WITH RESULTS ABOVE FINAL REMEDIATION LEVELS DURING 2003

Constituent	Number of Wells Exceeding the FRL	Number of Wells Exceeding the FRL Outside the 10-Year, Time-of-Travel Remediation Footprint	Groundwater FRL	Range of 2003 Data Inside the 10-Year, Time-of-Travel Remediation Footprint[a]	Range of 2003 Data Outside the 10-Year, Time-of-Travel Remediation Footprint[a]
General Chemistry			**(mg/L)**	**(mg/L)**	**(mg/L)**
Nitrate/Nitrite	3	0	11[b]	17.5 to 90.5	NA
Inorganics					
Antimony	3	3	0.0060	NA	0.00601 to 0.00629
Manganese	5	3	0.90	1.01 to 2.7	0.973 to 1.57
Molybdenum	1	0	0.10	0.422 to 0.494	NA
Zinc	4	4	0.021	NA	0.0215 to 0.0397
Volatile Organics			**(μg/L)**	**(μg/L)**	**(μg/L)**
Trichloroethene	1	0	5.0	41.7 to 62.4	NA
Radionuclides			**(pCi/L)**	**(pCi/L)**	**(pCi/L)**
Technetium-99	3	0	94	111 to 940	NA

[a]NA = not applicable
[b]FRL based on nitrate, from Operable Unit 5 Record of Decision, Table 9-4; however, the sampling results are for nitrate/nitrite.

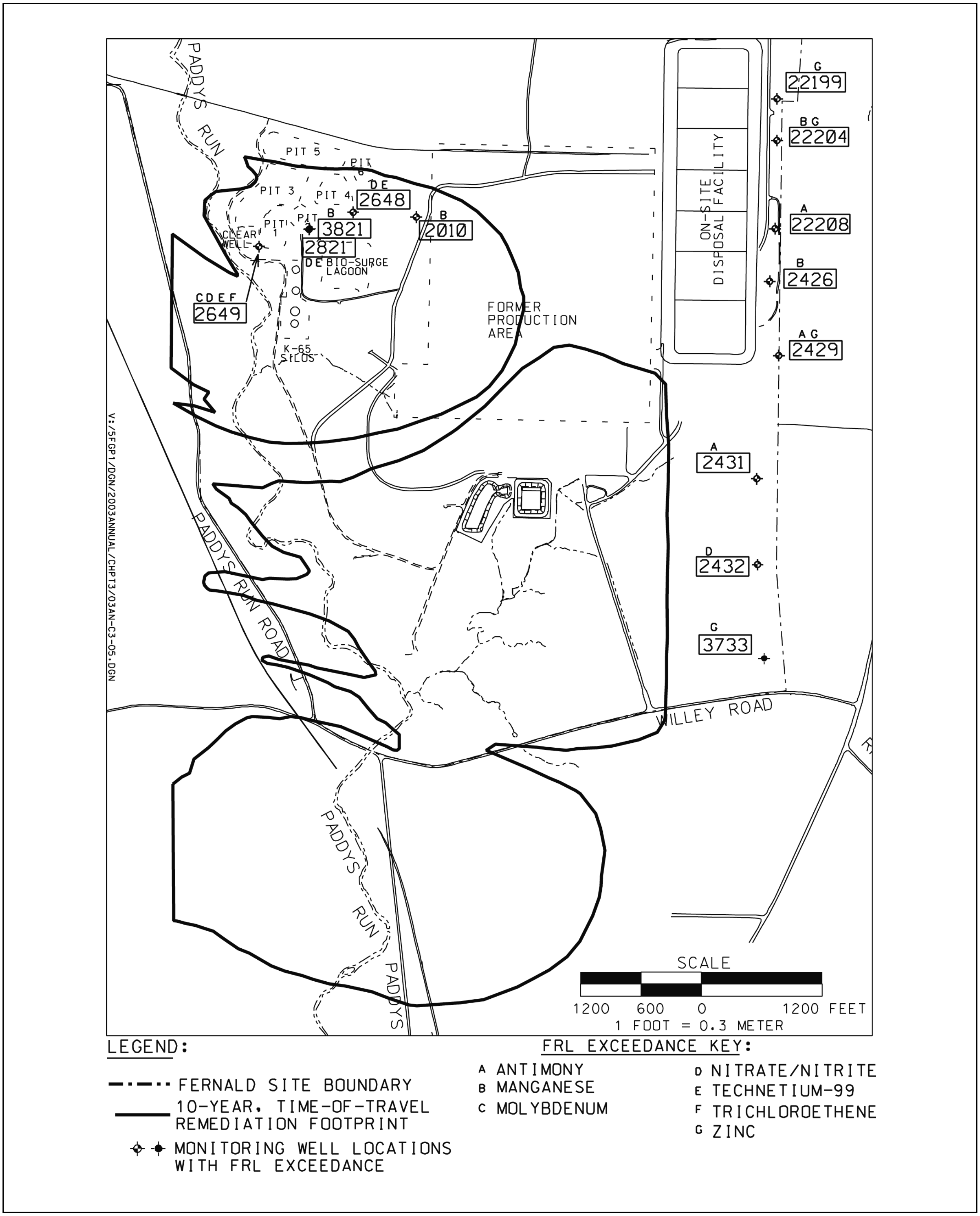


Figure 3-10. Non-Uranium Constituents with 2003 Results Above Final Remediation Levels

During 2003 non-uranium FRL exceedances were observed at 13 monitoring well locations as shown in Figure 3-10. A total of seven non-uranium FRL constituents exceeded FRLs in 2003. The Waste Storage Area exceedances will be further evaluated in the design of the Waste Storage Area (Phase II) Module. The exceedance locations along the eastern Fernald site boundary are outside the 10-year, time-of-travel remediation footprint. No plumes for the above-FRL constituents at the locations outside the 10-year, time-of-travel remediation footprint were identified in the extensive groundwater characterization efforts evaluated as part of the Remedial Investigation Report for Operable Unit 5 (DOE 1995c).

The constituents with FRL exceedances at the well locations outside the 10-year, time-of-travel remediation footprint were further evaluated to determine whether they were random events or if they were persistent according to criteria discussed in Appendix A, Attachment A.4, of this report. Only one of the exceedances in 2003 was classified as persistent (manganese at Monitoring Well 2426). All constituents formerly having persistent exceedances are no longer considered persistent since exceedances have not continued with subsequent sampling. Appendix A, Attachment A.4, of this report provides detailed information on non-uranium FRL exceedances and the persistence of these exceedances.

3.3.2 Other Monitoring Commitments

Two other groundwater monitoring activities are included in the IEMP:

- Private well monitoring
- Property boundary monitoring

As stated earlier, the groundwater data from these activities, along with the data from all other IEMP groundwater monitoring activities, are collectively evaluated for total uranium and, where necessary, non-uranium constituents of concern. The discussion that follows provides additional details on the two compliance monitoring activities.

The three private wells (Monitoring Wells 2060 [12], 13, and 14) located along Willey Road are monitored under the IEMP to assist in the evaluation of the uranium plume migration (refer to Appendix A, Attachment A.2, Figure A.2-1 for well locations). It was at one of these private wells that off-property groundwater contamination was initially detected in 1981. Monitoring stopped at the other private wells in 1997 because a DOE-sponsored public water supply became available to Fernald site neighbors who have been affected by off-property groundwater contamination.

The availability of the public water supply resulted in the plugging and abandonment of many private wells in the affected off-property areas where groundwater is being remediated. Data from the three private wells sampled under the IEMP were incorporated into the uranium plume map shown in Figure 3-9.

During 2003 Property/Plume Boundary Monitoring was comprised of 38 monitoring wells located downgradient of the Fernald site, along the eastern and southern portions of the property boundary. Twenty-seven Type 2 and 3 wells were monitored along the eastern Fernald site boundary and slightly downgradient of the South Plume to determine if any contaminant excursions were occurring. Eleven Type 2 and 3 wells were monitored in the Paddys Run Road Site area to document the influence, or lack thereof, that pumping in the South Plume was having on the Paddys Run Road Site Plume. Data from the property/plume boundary wells were integrated with other groundwater data for 2003 and were incorporated into the uranium plume maps shown Figure 3-9 and in Attachment A.2. Non-uranium data from these wells were included above in the section on monitoring results for non-uranium constituents.

Director's Findings and Orders were issued by OEPA on September 7, 2000. These orders specify that the site's groundwater monitoring activities will be implemented in accordance with the IEMP. The revised language allows modification of the groundwater monitoring program as necessary, via the IEMP revision process (subject to OEPA approval), without issuance of a new Director's Order. As determined by OEPA, the IEMP will remain in effect throughout the duration of remedial actions.

3.4 On-Site Disposal Facility Monitoring

Groundwater monitoring for the cells of the on-site disposal facility is conducted in the glacial till (perched water) and in the Great Miami Aquifer. Groundwater monitoring in support of the on-site disposal facility continued in 2003. This monitoring program is designed to accomplish the following:

- Establish a baseline of groundwater conditions in both the perched groundwater and the Great Miami Aquifer beneath each cell of the on-site disposal facility. The baseline data will be used to evaluate future changes in perched groundwater and Great Miami Aquifer groundwater quality to help determine if the changes are due to on-site disposal facility operations.
- Continue routine groundwater sampling following waste placement and cell capping as part of the comprehensive leak detection monitoring program for the on-site disposal facility. This information will be used to help verify the ongoing performance and integrity of the on-site disposal facility.

Table 3-3 summarizes the groundwater monitoring information associated with the on-site disposal facility. Table 3-3 also summarizes leachate collection system and leak detection system monitoring information. Sampling of the leachate collection system and the leak detection system is generally initiated after waste placement, while groundwater sampling is initiated before waste is placed in a particular cell. Table 3-3 provides information for Cells 1 through 6 along with sample information and range of total uranium concentrations. No constituents sampled to meet on-site disposal facility monitoring requirements exceeded groundwater FRL exceedances; however, several non-uranium constituents (antimony, manganese, and zinc), which are sampled to meet IEMP requirements exceeded their respective FRLs as identified in Section 3.3.1.7 (Monitoring Wells 22199, 22204, and 22208).

TABLE 3-3

ON-SITE DISPOSAL FACILITY GROUNDWATER, LEACHATE, AND LEAK DETECTION SYSTEM MONITORING SUMMARY

Cell (Waste Placement Start Date)	Monitoring Location	Monitoring Zone	Date Sampling Started	Total Number of Samples	Range of Total Uranium Concentrations[a] (µg/L)
Cell 1 (December 1997)	22201	Great Miami Aquifer	March 31, 1997	39	ND – 8.33
	22198	Great Miami Aquifer	March 31, 1997	58	0.557 – 11.5
	12338	Glacial Till	October 30, 1997	44	ND – 19
	12338C	Leachate Collection System	February 17, 1998	24	ND – 142.186
	12338D	Leak Detection System	February 18, 1998	23	1.5 – 23.2
Cell 2 (November 1998)	22200	Great Miami Aquifer	June 30, 1997	34	ND – 1.11
	22199	Great Miami Aquifer	June 25, 1997	35	ND– 12.1
	12339	Glacial Till	June 29, 1998	43	ND – 7.34
	12339C	Leachate Collection System	November 23, 1998	21	4.51 – 68.6
	12339D	Leak Detection System	December 14, 1998	21	8.69 – 71[b]
Cell 3 (November 1999)	22203	Great Miami Aquifer	August 24, 1998	32	ND – 7.92
	22204	Great Miami Aquifer	August 24, 1998	33	ND – 5.924
	12340	Glacial Till	July 28, 1998	36	ND – 29.3
	12340C	Leachate Collection System	October 13, 1999	18	9.27 – 83.7
	12340D	Leak Detection System	August 26, 2002	5	15.1 – 27.3
Cell 4 (November 2002)	22205	Great Miami Aquifer	November 5, 2001	20	0.446 – 19.7
	22206	Great Miami Aquifer	November 6, 2001	19	ND – 5.78
	12341	Glacial Till	February 26, 2002	15	4.89 – 7.91
	12341C	Leachate Collection System	November 4, 2002	3	4.41 – 55.1
	12341D	Leak Detection System	November 4, 2002	4	5.74 – 15.7
Cell 5 (November 2002)	22207	Great Miami Aquifer	November 6, 2001	19	ND – 4.48
	22208	Great Miami Aquifer	November 5, 2001	20	ND – 0.803
	12342	Glacial Till	February 26, 2002	16	10.3 – 21.1
	12342C	Leachate Collection System	November 4, 2002	5	3.39 – 97.5
	12342D	Leak Detection System	November 4, 2002	4	2.93 – 14.3
Cell 6 (November 2003)	22209	Great Miami Aquifer	December 16, 2002	13	ND – 2.38
	22210	Great Miami Aquifer	December 16, 2002	13	ND – 1.02
	12343	Glacial Till	March 14, 2003	10	ND – 10.9
	12343C	Leachate Collection System	October 27, 2003	2	8.03 – 78.6
	12343D	Leak Detection System	October 27, 2003	1	3.1

[a]ND = not detectable

[b]Data not considered representative of true leak detection system uranium concentrations in Cell 2 (December 14, 1998 through May 23, 2000 data set) due to malfunction in the Cell 2 leachate pipeline and the resultant mixing of individual flows.

During 2002 the Technical Memorandum for establishing baseline groundwater conditions for Cells 1 through 3 was issued and approved by the OEPA and EPA. Data in the memorandum establish initial groundwater conditions to be compared with future sampling results as part of the leak detection data evaluation process. As part of the memorandum process, changes to the sampling protocol for Cells 1 through 3 were recommended. The new sampling protocol for these cells was approved and implemented in the second half of 2002. Additionally in 2003, baseline sampling for Cells 4, 5, and 6 continued in the Great Miami Aquifer wells.

Placement of contaminated soil and debris in Cell 1 concluded at the end of December 2000 (Cell 1 was 100 percent full), and cap material was placed on Cell 1 through November 2001. Placement of contaminated soil and debris in Cell 2 concluded at the end of October 2002 (Cell 2 was 100 percent full), and cap material was placed on Cell 2 through October 2003. In 2003 soil and debris placement continued in Cells 3, 4, and 5, and began in Cell 6 in November 2003. At the end of December 2003, Cell 3 was approximately 98 percent full, Cell 4 was approximately 55 percent full, Cell 5 was approximately 9 percent full, and Cell 6 was approximately 9 percent full. Based on 2003 on-site disposal facility leak detection flow monitoring data collected from Cells 1 through 5, the liner systems are performing within the specifications outlined in the approved cell design.

Figure 3-11 identifies the on-site disposal facility footprint and monitoring well locations for Cells 1 through 6. For additional information on the groundwater, leak detection and leachate sampling results for the on-site disposal facility, refer to Appendix A, Attachment A.5, of this report.

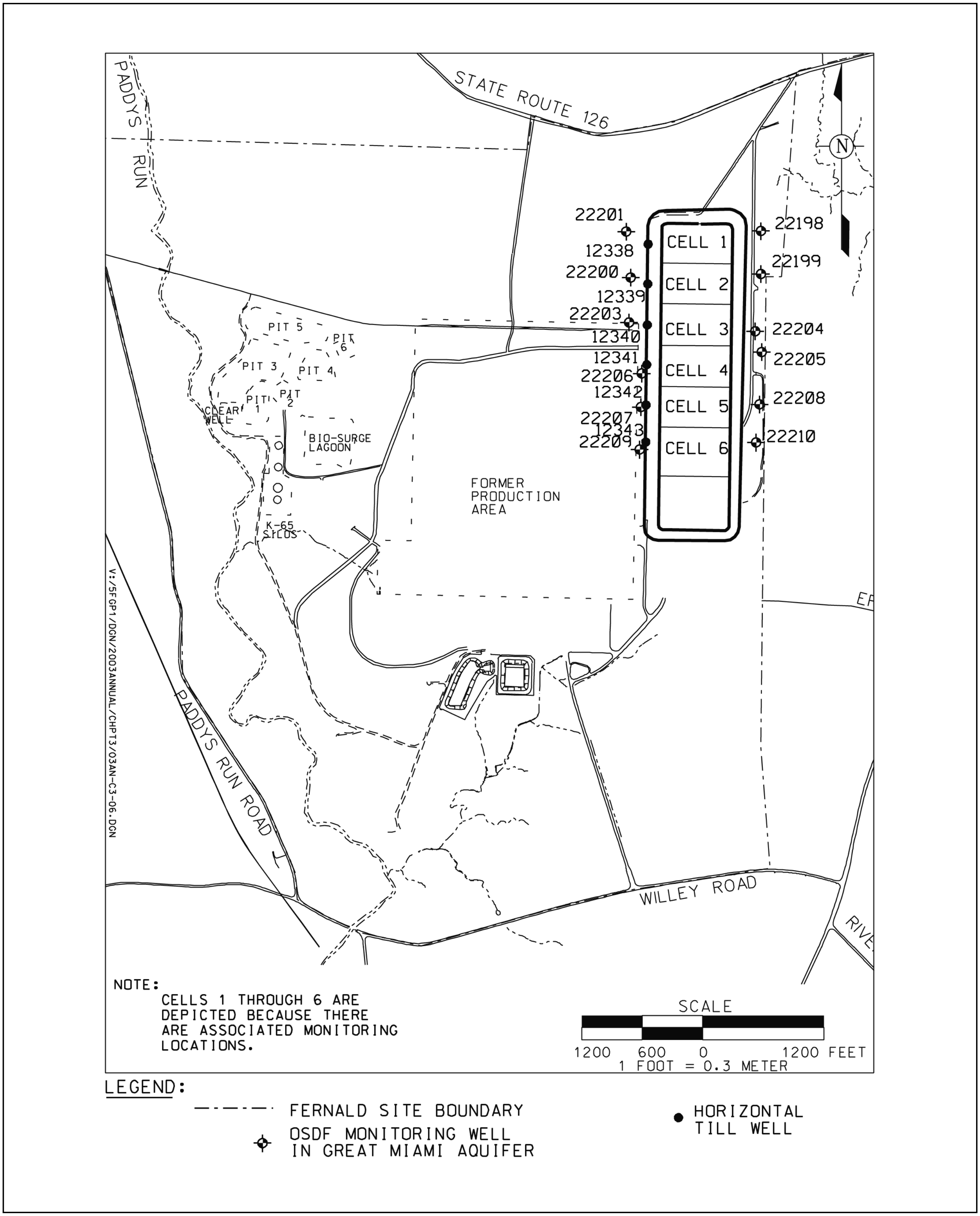


Figure 3-11. On-Site Disposal Facility Footprint and Monitoring Well Locations